

# What is a flood model?

Flood modelling predicts where water is likely to go, and how deep the flood may become for a given rainfall event. A flood model simulates the behaviour of stormwater and flood flows within drainage and waterway networks to estimate urban and floodplain inundation.



Flood models typically have a five to ten-year lifespan. Regular updates are required to account for changes to urban form, density, new standards, new modelling techniques and recent flood events.

## Flood forecasting

Flood modelling can also be used in flood forecasting. Flood forecasting involves predicting the likelihood, timing, and magnitude of flooding in a specific area. This is achieved using real-time data such as rainfall and river levels, combined with computer models and meteorological forecasts to simulate how water will move through the landscape. This can be used for emergency preparedness, flood warnings and emergency response during a large storm event.

## Information provided by flood models

Flood models provide valuable information that includes:

- flood extent (the areas that may be impacted)
- flood depth (how deep the flood may be)
- flood velocity (how quickly an area might flood and how fast the water may move).

## Data inputs for flood models

Flood models require various data inputs to accurately simulate flood scenarios, including:

- A representation of the terrain and landform features, ground cover (e.g. road and grass), waterways, drainage networks, flood control infrastructure and boundary conditions (e.g. tidal influence, starting water levels, infiltration rate)
- A suite of potential rainfall events that may be based on historic rainfall data and current and future climate conditions for the location.

## Flood models are simulated using computer software packages

Flood models are built based on the 2019 Australian Rainfall and Runoff guidelines. This process involves engineers and scientists performing hydrologic and hydraulic computations using computer models.

- Hydrologic models typically determine how much water is delivered via a catchment into the drainage network or riverine system.
- Hydraulic models represent the drainage network.

## Flood mapping

Flood mapping involves creating detailed maps that show the extent, depth and velocity of flooding that could occur in a specific area, given a particular amount of rainfall. Information such as historical rainfall records and computer models are used to simulate how water would behave in different flood scenarios. Flood maps may be used for land use planning, statutory planning, emergency management, community awareness and flood mitigation works.

Flood mapping may involve hydrologic and hydraulic investigations and a statistical analysis of how often floods have happened. Melbourne Water has initiated the *Flood Management Strategy Port Phillip and Westernport, Action Plan 2021-2026*, which aims to partner with councils to map all municipalities using the best flood modelling standards.

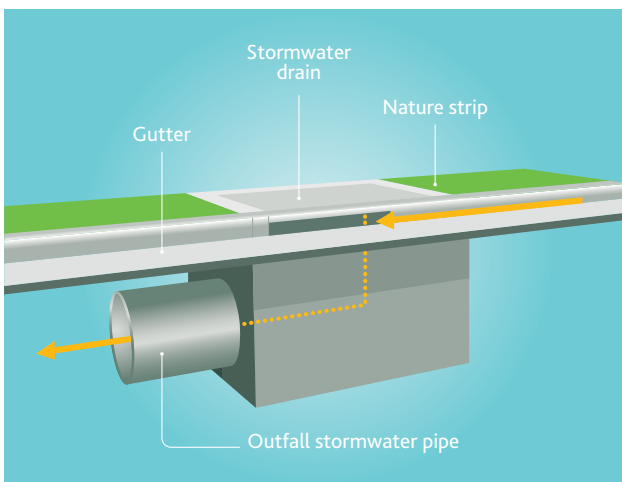
## Types of models

There are 1D and 2D flood models. Typically, an area will be modelled with the underground drainage pipes and pits in the 1D model, and the ground surface modelled in the 2D model.

Figure 1 - Differences between 1D and 2D models



**1D models** show how the water will move in one dimension within a pipe or channel, with their best application being for pipes and open channels or waterways where the direction of flow is known and predictable.



**2D models** show how the water will move in two dimensions. The model can predict which direction the water will spill and move across a surface, and how deep it will be.

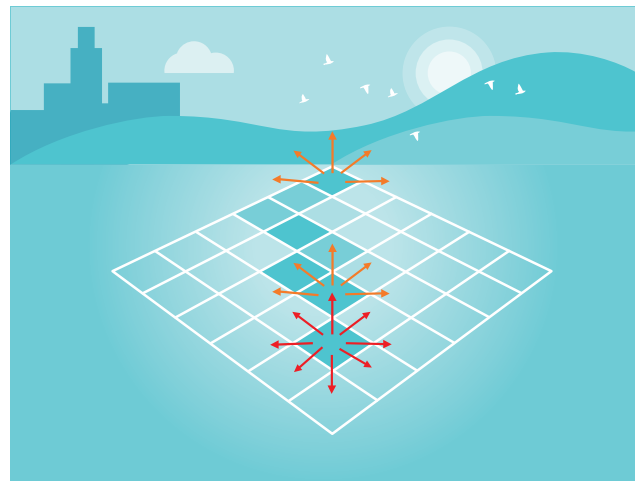
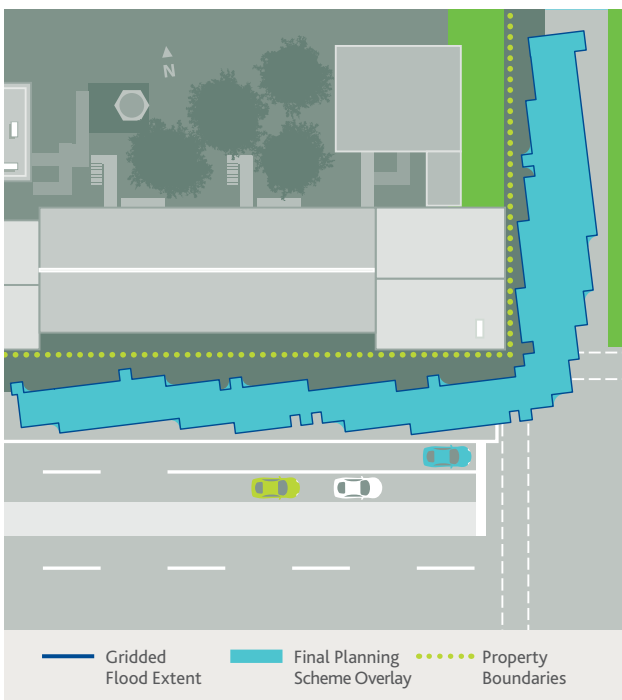


Figure 2 - How does a model generate a flood extent?



To generate a flood extent, a computer flood model begins by gathering input data on rainfall, topography, and water flow infrastructure. High-resolution digital elevation models (DEMs) are used to understand the terrain and how water will move across it.

Rainfall data, both current and forecasted, are fed into the model to simulate the volume of water entering the system. The model incorporates information about drainage systems and waterways to understand how these channels will convey water and where they might overflow. It also considers land use patterns, distinguishing between permeable surfaces like soil and impermeable surfaces like concrete, which affect runoff rates.

Using complex algorithms and hydraulic equations, the model calculates the depth and velocity of water at various points. The final step involves producing flood maps that show the spatial extent of flooding, depths of inundation, and the duration of the flood. These maps are critical for hazard risk assessment, planning, mitigation, education and response by providing a visual representation of where there are potential flood impacts.

Figure 3 - How does a flood model work?

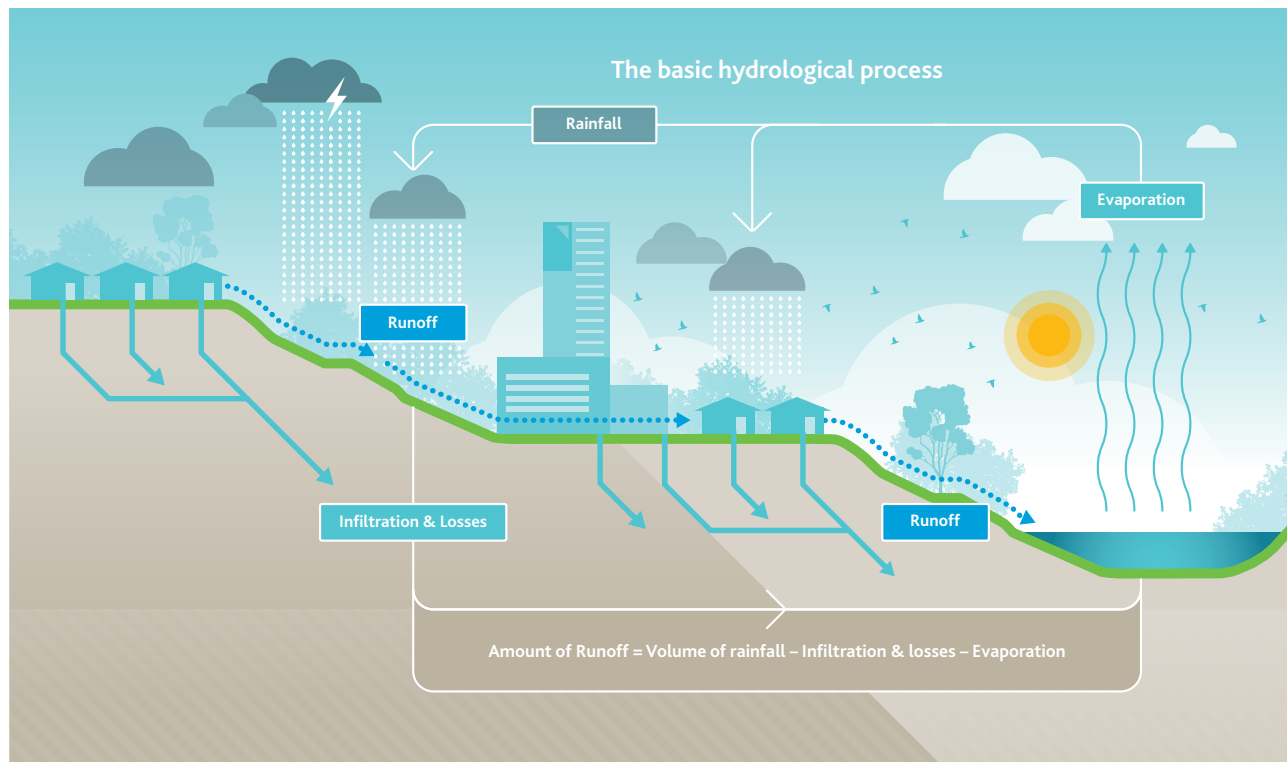


Figure 4 - Flood model data inputs





Police Road (David Hannah)



Heatherton Road  
Dandenong (Ben Swinerton)

## Types of flooding

There are different types of flooding, each with unique characteristics and different impacts on the environment and community<sup>1</sup>:

- **Waterway flooding** – happens when widespread, prolonged rain falls over the catchment of a river. Inundation of normally dry land occurs when water overtops the natural or artificial banks of a stream, river, estuary, lake or dam. Waterway flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels. Riverine flooding can be a slower process, occurring at a rate that allows advance warning, depending on the catchment size. Flood waters may last for days. Versus creek flooding which can rise quickly and be very fast moving, and then recede quickly.
- **Stormwater flooding** – inundation by local runoff caused by heavier than usual rainfall. Inundation can be caused by local runoff that exceeds the capacity of urban stormwater drainage systems; overland flows that are on the way to waterways; or riverine flooding causing urban stormwater drainage systems to back up and overflow. Flash flooding from the stormwater system tends to be rapid and dangerous due to the speed and depth of flows and difficulty in providing a timely warning to people.
- **Coastal flooding** – increases in coastal water levels above the predicted tide level resulting from a range of storm-related factors such as wind and waves. Coastal flooding in a storm surge gives some advance notice but sea level rise will mean some areas are permanently underwater.

## Understanding flood risk and modelling challenges

Flood risk is a natural hazard and there is no single solution to managing it. Across the Port Phillip and Westernport region it is estimated there are over 200,000 properties that have at least a 1% chance of flooding each year. Of those properties, more than 20,000 have a 1% chance of experiencing above floor flooding each year.

**Flood models are tools designed to simulate real-world flood scenarios. While they provide valuable insights into potential flood impacts, it's important to recognise that they operate within a range of uncertainties inherent in modelling complex natural processes and therefore simulating real-world scenarios is not the same as a real-world event.**

- Rainfall events are not identical, and assumptions are made to determine likely events. Catchment conditions during a flood can significantly influence the behaviour of floodwater, particularly regarding blockages and obstructions that may be present.
- Building large scale infrastructure to reduce flooding remains an important solution, however it is not the only mechanism. Other tools such as effective town planning, community education programs and flood warning systems can provide a more effective way to manage flood impacts.<sup>2</sup>

### Ground cover permeability

Ground cover, such as grass and pavement, plays an important role in flood modelling. It is expected that rain falling on an open grassed area will partially drain into the soil, while the majority of rainfall on a hard surface such as a carpark will run off. However, other local parameters, such as the soil's infiltration rate and the water table depth, also play an important role in determining how much runoff occurs and how much water infiltrates.

In modelling terms, this is referred to as the impervious area, which is the ability of the ground type to absorb water. Within a flood model, every portion of the model is assigned an impervious value that instructs the computer model how much of the rainfall that lands should run off and how much should soak in.

Models can also account for how wet the soil is prior to a large storm event. The saturation of the soil can also impact how much of the rain that falls will runoff.

<sup>1</sup> Internal Position Paper: Inundation Overlays PSA – Explaining 1% AEP, *Flood Type and Probability (2019)*, City of Melbourne

<sup>2</sup> *Communicating Flood risk to the Community*, Melbourne Water

## Flood standards and setup

Flood modelling follows industry standards and best practices. In Australia, the guidelines for flood modelling and mapping are given by the Australian Rainfall and Runoff, 2019. Melbourne Water and councils may also have their own guidelines that provide a consistent and localised approach. Flood models may also be subject to peer review to ensure their accuracy.<sup>3 4</sup>

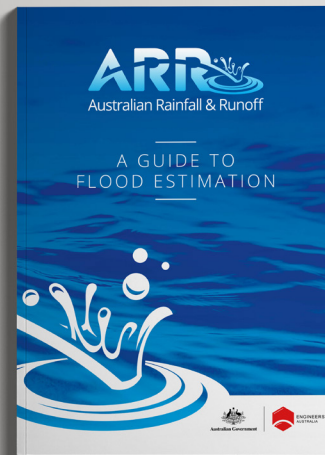
### Annual exceedance probability and average recurrence interval

The size of a flood is usually characterised by its peak flow. In turn, the peak flow is related to how often different sized floods occur. Small floods are reasonably common while large floods are generally rare. The link between flood size and frequency of occurrence can be expressed as a probability or as the average time period between floods. Two common terms that help us understand the likelihood and frequency of floods:

- Annual Exceedance Probability (AEP) is the probability that a flood flow will be exceeded in any one year. For example, a 1% AEP flood means there is a 1% chance that a certain flood flow will be exceeded in any one year.
- Average Recurrence Interval (ARI) is the average number of years between floods of a certain size. A 1% AEP flood will occur on average once every 100 years.

Note that recurrence interval is a long-term average. Informally, a 1% AEP may be referred to as a '100-year flood', however this does not mean there will be exactly 100 years until the flood happens again. There is a 1% chance that a 1% AEP flood could happen in any year.

Figure 5 - Australian Rainfall and Runoff



*Australian Rainfall and Runoff:  
A Guide to Flood Estimation, 2019*



3 Draft Manningham Flood Mapping Project Key Messages

4 Inundation Overlays PSA - Flood Modelling Methodology and Mapping (2019), City of Melbourne

Figure 6 - 'Australian Rainfall & Runoff' preferred terminology

| Frequency Descriptor                                                                            | EY     | AEP (%) | AEP       | ARI    |
|-------------------------------------------------------------------------------------------------|--------|---------|-----------|--------|
|                                                                                                 |        |         | (1 in x)  |        |
|  VERY FREQUENT | 12     |         |           |        |
|                                                                                                 | 6      | 99.75   | 1.002     | 0.17   |
|                                                                                                 | 4      | 98.17   | 1.02      | 0.25   |
|                                                                                                 | 3      | 95.02   | 1.05      | 0.33   |
|                                                                                                 | 2      | 86.47   | 1.16      | 0.5    |
|                                                                                                 | 1      | 63.21   | 1.58      | 1      |
|  FREQUENT      | 0.69   | 50      | 2         | 1.44   |
|                                                                                                 | 0.5    | 39.35   | 2.54      | 2      |
|                                                                                                 | 0.22   | 20      | 5         | 4.48   |
|                                                                                                 | 0.2    | 18.13   | 5.52      | 5      |
|                                                                                                 | 0.11   | 10      | 10        | 9.49   |
|  RARE         | 0.05   | 5       | 20        | 19.5   |
|                                                                                                 | 0.02   | 2       | 50        | 49.5   |
|                                                                                                 | 0.01   | 1       | 100       | 99.5   |
|  VERY RARE   | 0.005  | 0.5     | 200       | 199.5  |
|                                                                                                 | 0.002  | 0.2     | 500       | 499.5  |
|                                                                                                 | 0.0001 | 0.1     | 1000      | 999.5  |
|                                                                                                 | 0.0005 | 0.05    | 2000      | 1999.5 |
|                                                                                                 | 0.0002 | 0.02    | 5000      | 4999.5 |
|  EXTREME     |        |         | ↓         |        |
|                                                                                                 |        |         | PMP       |        |
|                                                                                                 |        |         | PMP Flood |        |

-  Terminology often used in Water Sensitive Urban Design (WSUD)
-  Terminology often used in floodplain management and waterway design
-  Terminology often used for critical infrastructure, such as dam design
-  Preferred terminology

EY: Exceedances per Year - number of times an event is expected to exceed in a year.

PMP: Probable Maximum Precipitation - the maximum possible rainfall over a catchment.

AEP: Annual Exceedance Probability - likelihood of an event being exceeded annually (e.g., 1% AEP = 1 in 100 year event).

ARI: Average Recurrence Interval - average time between events of a certain magnitude (e.g., 100-year ARI = 1% AEP).

## Collaboration

Collaboration is an important part of the flood modelling process. Flood modelling practitioners work together with organisations such as the Bureau of Meteorology, Geoscience Australia, researchers, and other practitioners to develop and update guidelines and standards for flood modelling, such as the *Australian Rainfall and Runoff, 2019*.

**Collaboration between different organisations and stakeholders, such as Melbourne Water, councils and the community, can help to ensure that flood modelling is well-funded, well-coordinated, accepted and effectively communicated to the community.**<sup>5 6 7 8</sup>

Ongoing collaboration and communication are needed to help keep flood models updated with any major developments, drainage network and terrain changes that may have an impact on flood behaviour.

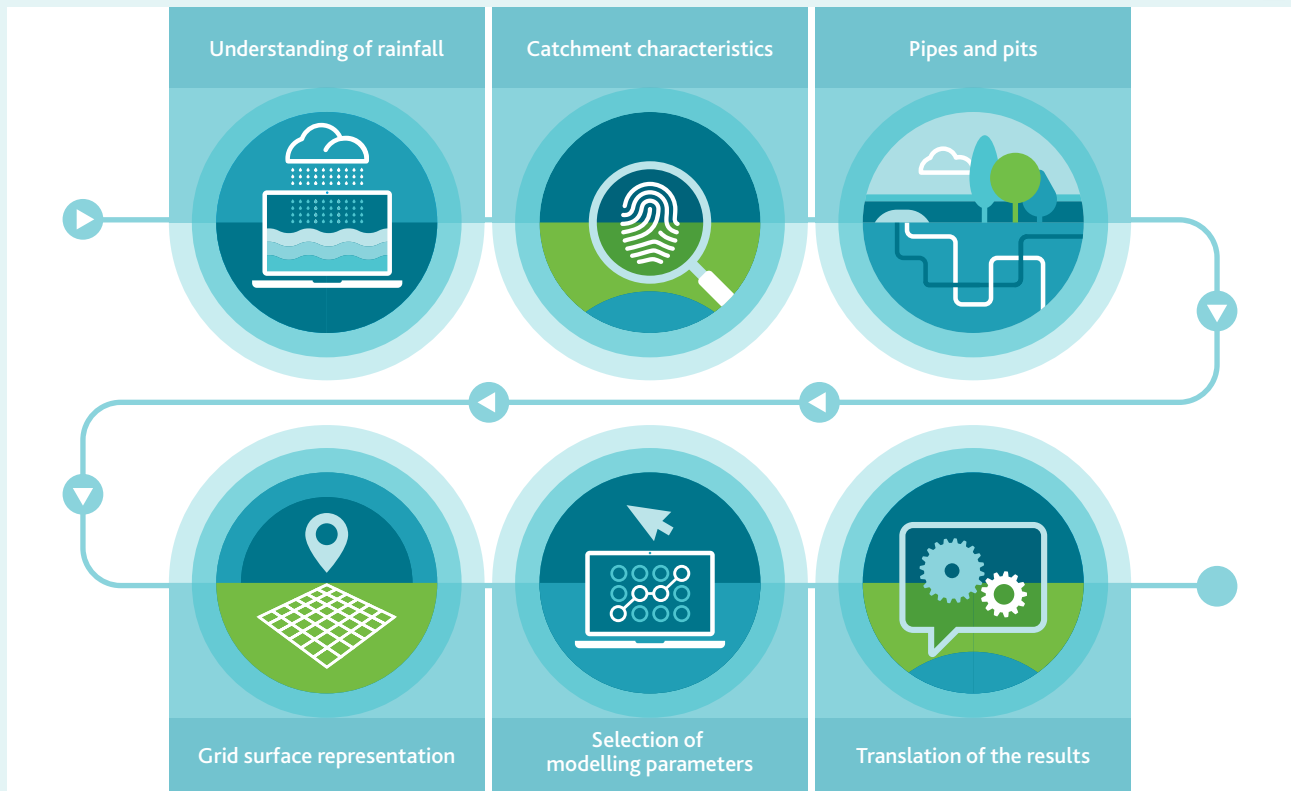
Both Melbourne Water and councils complete flood modelling, often in joint projects. A large amount of information is generated from flood modelling, but its main purpose is to communicate where floods may occur, how deep the water could be, and how fast it might move. Some modelling will also show the difference between current conditions and how we may be impacted by a changing climate.

The models incorporate the best science and data and require intermittent updating to ensure that they're current.

## Community consultation

Community consultation can enhance flood models by providing local insights and knowledge that may not be captured through technical data alone. The *Victorian Floodplain Management Strategy, 2016* emphasises the need for community consultation to inform flood models.

Figure 7 - Flood model inputs



5 AM STA 6200 Flood Mapping Project Specifications: Standard (2023), Melbourne Water

6 Flood Modelling Project Funding Agreement, Melbourne Water

7 Inundation Overlays PSA - Flood Modelling Methodology and Mapping (2019), City of Melbourne

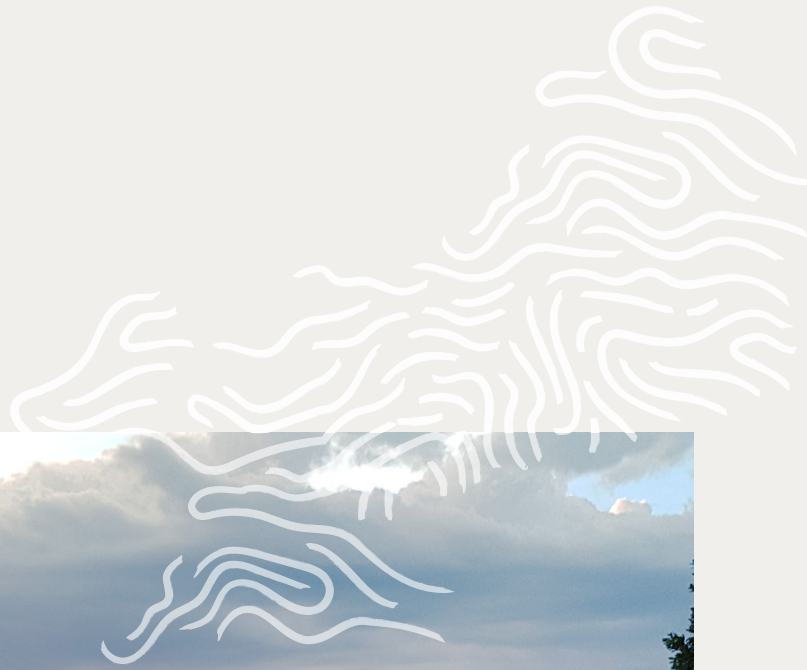
8 Flood Management Strategy 2021-31 - Action Plan 2021-26, Melbourne Water

## Updating models

Updates to a model are necessary to ensure accuracy and reliability. These updates may occur when there are:

- changes in the catchment
- significant developments or land use changes
- updates in guidelines such as *Australian Rainfall and Runoff, 2019*
- new data from recent rainfall events or climate change projections
- advances in modelling techniques or technology.

Regular updates help maintain the model's relevance and improve its predictive capabilities.



Chelsea Road, Chelsea 2007  
(Luke Cunningham, Rain Consulting Pty Ltd)